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ABSTRACT

Gagne proposed in his learning hierarchy model that a final task could not be performed by an individual who does not have the subordinate skills, and that any superordinate task involved in the hierarchy of skill building could be performed by an individual provided suitable instructions were given, and provided the relevant subordinate knowledge could be recalled by that individual. This particular theory of knowledge acquisition was investigated using a learning hierarchy of kinematics that had been previously validated through other research. A pilot study with students in grades five through eight was conducted, and 173 fifth and sixth graders were selected to participate in this study. The study began with a pretest that evaluated the subjects' abilities in subtraction, division, and seven additional skill areas. An instructional booklet taught subjects all the skills but the one(s) they were supposed to skip according to their treatment groups. A posttest was then administered to examine subjects on five items for each skill that was taught. A 4 x 2 factorial design was used--four levels of skipping treatment were crossed with two levels of mathematics ability--and ANOVAs were used to determine significant differences among the dependent measures. The hypothesis was supported that skipping one or more subordinate skills does not affect some learners' performance on the skipped skills and the skill above them. It was found that subjects' performance in a skipping condition depends on the content-related ability of the individual, and the size and type (coordinate or subordinate) of skip. (9 references) (CGD)

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Factors Related To The Skipping of Subordinate Skills in Gagne's Learning Hierarchies

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Statement of the Problem

In 1962, Gagne introduced the learning hierarchy model as a theory of knowledge acquisition. He suggested that a skill could not be acquired unless the learners possessed certain prerequisite skills, which were identified by asking the question "What would the individual have to be able to do in order that he can attain successful performance on this task, provided that he is given only instructions?" (p.358). The same question was then applied to each prerequisite skill. As a result, a hierarchy could be derived.

In the same article, Gagne proposed that the learning hierarchy theory had two hypotheses: "a) no individual could perform the final task without having these subordinate capabilities...; and b) that any superordinate task in the hierarchy could be performed by an individual provided suitable instructions were given, and provided the relevant subordinate knowledge could be recalled by him" (p. 356).

Although Gagne (personal communication, January, 1988) argued that the fourth edition of his book The Conditions of Learning (1985) provided a more updated and refined account of the hierarchy theory, a close examination indicated that the fundamental points remained the same (Yao, 1989).

In 1968 Gagne published another important article about the learning hierarchy. In this article, he pointed out that a learning hierarchy could not represent a unique or most efficient route for any given learner. Instead, what it represents is the most probable expectations of greatest positive transfer for an entire sample of learners. An individual learner does not necessarily have to acquire each subordinate skill precisely in hierarchical sequence in order for him to learn the final task.

He further explained that nothing in the analysis method which derives the hierarchies told us about the capabilities of the individual learners. Therefore, he stated that "a given individual may be able to 'skip' one or more of the subordinate tasks, just as a given learner may be able to 'skip' parts of an adaptive program of instruction [p.3 (Gagne, 1968)]."

However, this important point has been ignored by most people since it was first addressed by Gagne. Many learning hierarchies researchers have focused their investigations on testing the validity of hierarchies. A review of the literature on learning hierarchies has revealed that the skipping of subordinate skills has never been studied (Yao, 1989).

Focus of the Study

The purpose of this study was to investigate the following two issues:

1. Can some learners skip?
2. What are the factors that influence a given individual's potential for skipping?

Skipping in this study is defined as 1) from instructional perspective, a situation where instruction on one or more skills in a learning hierarchy is omitted, and 2) from the learner's perspective, the capability to obtain on one's own the skills that are omitted from instruction and the superordinate skill to those skills.

The hypotheses and questions this study attempted to examine included:

1. Some learners can skip one or more subordinate skills of a given hierarchy and still achieve the terminal objectives.

2. The extent to which a learner can skip depends on 1) the individual's content-related ability and 2) the skipping size, defined as the number of skills skipped.

   2.1 Learners perform less well when the skipping size is large or when more skills are skipped.

   2.2 Higher-ability learners perform better than lower-ability learners on the skipped skill(s) and on the superordinate one(s).

The Hierarchy

This study requires the use of a learning hierarchy that has already been validated. A hierarchy of kinematics (see Figure 1 and Table 1) was chosen because it has been validated by White (1974), White and Gagne (1978), and Dick (1980), and has been used in 2 other studies (Kee & White, 1979; Trembath & White, 1978-79).

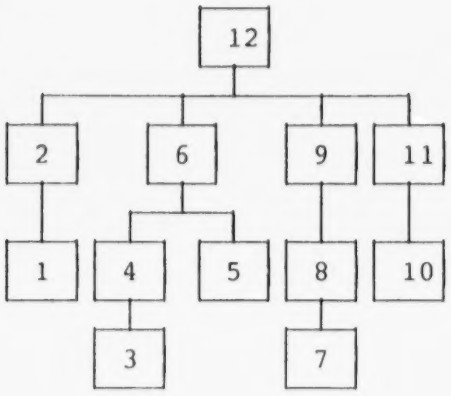
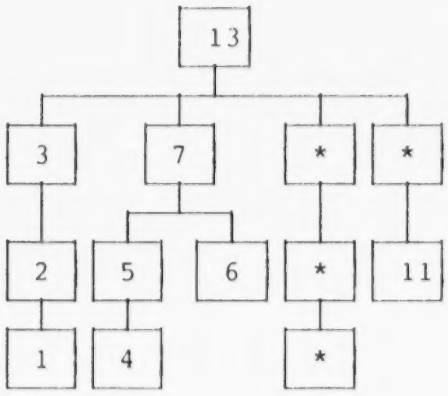


Figure 1
The Original Hierarchy



(* eliminated)

Figure 2
The Revised Hierarchy

However, a few modifications were made in the hierarchy actually used in the experiment (see Figure 2 and Table 1):

1. Skill #2 in the original hierarchy was broken down into 2 skills (#2 and #3) in the revised hierarchy.

2. Skill #7, #8, and #9 in the original hierarchy were eliminated from the actual hierarchy because they have been invalidated in all of the 3 validation studies mentioned above. The explanations offered by the researchers was that these elements are in the domain of verbal knowledge, not of intellectual skills, to which learning hierarchies apply.

   These three elements define the slope of a line on a position-time graph as the speed of the movement represented by that line. By eliminating these elements, students would be given the formulae to calculate the speed directly without involving the slope at all.

3. Skill #11 in the original hierarchy was eliminated in the revised hierarchy in order to simplify the treatment and to have better control of the experiment. Skill #11 deals with the unit of speed. To take care of this gap, the units were provided throughout the instructional booklet and the posttest.

Table 1: Elements of the Hierarchies

The Original Hierarchy	The Revised Hierarchy
1. Finds time after start on a position-time graph.	1. Finds time after start on a time line.
	2. Finds time after start on a position-time graph.
2. Calculates time interval between two points on a position-time graph.	3. Calculates time interval between two points on a position-time graph.
3. Finds displacement from start on position axis of a position-time graph.	4. Finds displacement from start on a position line.
4. Finds displacement from start on a position-time graph.	5. Finds displacement from start on a position-time graph.
5. Calculates displacement between two points on a position line.	6. Calculates displacement between two points on a position line.
6. Calculates displacement between two points on a position-time graph.	7. Calculates displacement between two points on a position-time graph.
7. States that line with biggest slope in position-time graph represents biggest velocity.	8. (eliminated)
8. Grades lines on position-time graph in order of velocities.	9. (eliminated)
9. States slope of position-time graph is velocity.	10. (eliminated)
10. Calculates slope of line given vertical and horizontal intercepts.	11. Calculates slope of line given displacement and time interval.
11. Calculates slope of line with units.	12. (eliminated)
12. Calculates velocity represented by straight line on position-time graph.	13. Calculates speed represented by straight line on a position-time graph.

Pilot Study

After the hierarchy was chosen, a pilot study was conducted in order to:

* improve the experimental instruments.
* select the appropriate grade level(s) for this particular hierarchy.
* find out the amount of time needed for the treatment.

Forty-five students from grades 5, 6, 7, and 8 participated in the pilot study, in which the 7th and 8th graders took only the pretest, and the 5th and 6th graders took the pretest and read the instructional booklet. The results of the pilot study showed that:

* most of the 7th and 8th graders and a few 5th and 6th graders had mastered all the skills in the hierarchy.

* most of the 5th and 6th graders had mastered the basic skills (i.e., subtraction and division) necessary for the learning of the skills in the hierarchy.

Based on the results of the pilot study, the 5th and 6th grades were chosen as the appropriate grade level for the experiment.

Experimental Materials

The instruments in this study included:

1. A pretest, which tested the subjects on subtraction (5 items), division (5 items), skill #1 (2 items), skill #2 (6 items), skill #3 (3 items), skill #4 (2 items), skill #5 (6 items), skill #6 (2 items), and skill #7 (3 items).

2. An instructional booklet, which taught subjects all the skills but the one(s) they were supposed to skip according to the treatment they were assigned into. For each skill that was taught, instructions were presented followed by practice items and, then, feedback (i.e., the correct answer and solution to the problem). For the skill that was to be skipped, two questions were presented, but no feedback was given. Subjects were only asked to solve the problem on their own.

3. A posttest, which tested subjects on skills #2, #3, #5, #7, #11, and #13 (5 items for each skill).

Procedure

One hundred and seventy-three (173) 5th and 6th grade students participated in the experiment. Among them, 93 were in 6th grade and 80 were in 5th grade. Mathematics scores from the California Achievement Test (CAT) were obtained for each participant, which included computation, concept & application, and total grade equivalent scores.

All 173 subjects took the pretest one week prior to the treatment. Based on the pretest results, a profile of the entry level performance was obtained for each subject. This profile contained the pass/fail pattern for each skill tested in the pretest. Table 2 lists the patterns for skills #2, #3, #5, and #7, which were particularly critical to the experiment.

Out of these 173 participants, 32 (24 in 6th grade and 8 in 5th grade) had possessed all the skills in the hierarchy. Their data were excluded from final analysis. This left 141 subjects whose data were to be used.

Based on the math total grade equivalent scores from CAT, these 141 subjects (5th and 6th graders combined) were divided into 2 groups: higher and lower ability. The scores ranged from 2.8 to 12.0 and the median score for the entire group (5.9) was used as the cutting point to divide the groups. The resulting means of the math total scores for the higher-ability group was 7.44 ($n = 69$) and for the lower-ability group was 4.92 ($n = 72$).

Based on subjects' entry level profile, each of the 141 individuals was further assigned into one of four treatment groups. The rule for the assignment was: a subject could not be assigned into a treatment which was going to skip the skill(s) he/she already possessed.

The treatment lasted for 2 days, 1 class session on each day. On Day 1, subjects read Part 1 of the instructional booklet. On Day 2, they finished Part 2 of the booklet and then took a posttest.

Research Design

A 4 x 2 factorial design was used. Four levels of skipping treatment were crossed with two levels of mathematics ability (higher and lower). The four treatments included:

* Treatment 1 -- skipped skills #3 and #7
* Treatment 2 -- skipped skill #3
* Treatment 3 -- skipped skills #2 and #3
* Treatment 4 -- skipped none (control group)

Seven dependent measures were used. These measures came from individual scores for the six skills tested in the posttest (#2, #3, #5, #7, #11, and #13) and a total score by adding these six scores together.

Table 2:
Pass/Fail Patterns for Skills #2, #3, #5, & #7 in Pretest

Pattern	Skill #2	#3	#5	#7	# of Ss	Available Treatments
a.	+	+	+	+	32	none
b.	-	+	+	+	1	T4
c.	+	-	+	+	5	T2,T4
d.	+	+	-	+	2	T4
e.	+	+	+	-	7	T4
f.	-	+	-	+	1	T4
g.	+	-	+	-	15	T1,T2,T4
h.	-	+	+	-	1	T4
i.	-	-	+	+	29	T2,T3,T4
j.	+	+	-	-	10	T4
k.	+	-	-	-	7	T1,T2,T4
l.	-	-	+	-	13	T1,T2,T3,T4
m.	-	+	-	-	7	T4
n.	-	-	-	+	2	T2,T3,T4
o.	-	-	-	-	41	T1,T2,T3,T4
					Total: 173	

(+ : Pass; - : Fail)

T1: skipped skills #3 and #7
T2: skipped skill #3
T3: skipped skills #2 and #3
T4: skipped none

Research Results

ANOVA's were conducted on all of the 7 dependent measures. A summary of the results is presented in the table below. Whenever significant differences occurred, Scheffe's post hoc analysis was used for pairwise and complex comparisons.

Table 3: Summary of ANOVA Results

Variables	Treatment	Ability	2-way Interaction
Skill-2	F(3,133)=2.425 p = 0.069	F(1,133)=22.784 p = 0.000**	F(3,133)=1.603 p = 0.192
Skill-3	F(3,133)=4.161 p = 0.007*	F(1,133)=31.184 p = 0.000**	F(3,133)=2.595 p = 0.055
Skill-5	F(3,133)=0.849 p = 0.469	F(1,133)=9.460 p = 0.003**	F(3,133)=1.348 p = 0.262
Skill-7	F(3,133)=1.745 p = 0.161	F(1,133)=14.160 p = 0.000**	F(3,133)=1.195 p = 0.314
Skill-11	F(3,133)=1.735 p = 0.163	F(1,133)=18.314 p = 0.000**	F(3,133)=0.359 p = 0.783
Skill-13	F(3,133)=1.361 p = 0.257	F(1,133)=19.427 p = 0.000**	F(3,133)=0.292 p = 0.831
Total	F(3,133)=1.638 p = 0.184	F(1,133)=33.841 p = 0.000**	F(3,133)=1.148 p = 0.332

* significant at 0.01 level
** significant at 0.005 level

The results of the ANOVA's indicated that the ability effect was highly significant ($p < 0.005$) on all dependent measures. However, analyses showed no significant treatment effect on any dependent measures except skill #3 ($p = 0.007$). A treatment-by-ability interaction was also found on skill #3 ($p = 0.055$).

Multiple comparisons using the Scheffe method were conducted on skill #3 to identify which means were significantly different. Results indicated that treatment groups 3 and 4 were significantly different from each other ($p = 0.014$), and the control group (treatment 4) was different from the other three skipping groups combined ($p = 0.015$).

Discussion

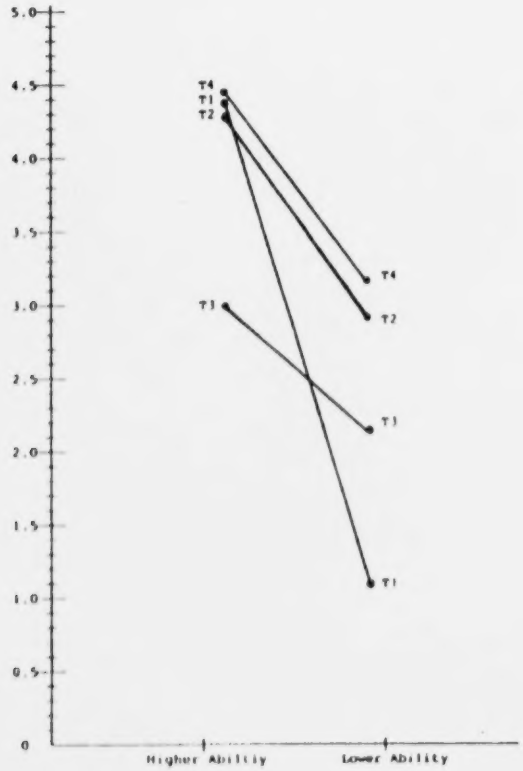
The results generally agreed with the hypothesis that some learners can skip, and highly supported that a learner's ability can influence his or her performance in a skipping situation. In this study, higher-ability learners outperformed lower-ability learners on the skipped skills (#2, #3, and #7) and on the superordinate one (#13). Furthermore, no skipping effect was found on skills #2 and #7, which were skipped in treatment 3 and treatment 1 respectively, and on the superordinate skill #13. In other words, regardless of whether skill #2 and skill #7 were skipped, no effect was found on subjects' performance on these two skills and the superordinate skill #13 when compared to the non-skipping group. This suggested that higher-ability subjects who did not learn one of these skills were able to "fill in the gap".

Significant treatment effect, however, was found on skill #3. This effect was contributed by the mean differences between treatment groups 3 and 4, and between the three skipping groups combined and the control group. That is, when skills #2 and #3 were skipped (treatment 3), subjects performed significantly less well than the non-skipping group on skill #3. Since skill #2 is subordinate to skill #3, this finding suggested that when both the subordinate (#2) and its superordinate (#3) skills were skipped at the same time, subjects were less able to fill in the gap. This applied to both higher-ability and lower-ability learners.

Furthermore, it should be noted that although the composite mean of the three skipping groups differed significantly from the non-skipping group, no significant differences were found when treatment groups 1 and 2 were individually compared to the control group. This may be due to the fact that all three skipping conditions involved skill #3: treatment 1 skipped skill #3 and a coordinate skill #7 (horizontal skipping); treatment 2 skipped skill #3; treatment 3 skipped skill #3 and a subordinate skill #2 (vertical skipping). This finding suggested that skipping skill #3 and another skill directly related to it significantly decreased subjects' performance on this skill when compared to the non-skipping group.

It should also be noted that larger skipping size did not necessarily affect subjects' performance in an equal manner. For example, both treatment 1 and treatment 3 skipped two skills, but only subjects in treatment 3 performed significantly less well than the non-skipping group on skill #3. This findings suggested that in addition to the skipping size, the type of skipping (e.g., horizontal or vertical) may also affect a learner's performance in a skipping condition.

Figure 3: Treatment-by-ability Interaction for Skill #3 Scores



Since a treatment-by-ability interaction existed on skill #3, group means were plotted in Figure 3. This figure interestingly revealed that lower-ability subjects were adversely affected more by the skipping condition in treatment 1 than in others. There was a drastic drop of performance by lower-ability learners when both skills #3 and #7 were skipped. This implied that skill #7, a coordinate to skill #3, might be more critical for lower-ability learners to obtain skill #3 than the subordinate skill #2. This result, though ungeneralizable to other instances where different hierarchies are used, suggested that different skipping conditions variously affected learners with different abilities.

In summary, the results of this study supported the hypothesis that skipping one or more subordinate skills does not affect some learners' performance on the skipped skills and the skill above them. Subjects' performance in a skipping condition depends on the content-related ability of the individual, the skipping size, and the type of skipping (coordinate or subordinate).

Implications for Instructional Design and Future Research

This study offered some rough guidelines in prescribing instruction or learning assignments to learners. Firstly, teachers and instructional designers may save higher-ability learners some time by omitting instruction on certain skills. In so doing, learning efficiency for those learners can be increased without degrading their learning performance.

Secondly, to facilitate a learner's performance in a skipping condition, selection of the skill(s) to be skipped can be crucial. If more than one skill is to be skipped, horizontal skipping (i.e., the skipping of a skill and its coordinate) may result in better performance than vertical skipping (i.e., the skipping of a skill and its immediate subordinate). This guideline, however, applies only to higher-ability learners. Results of the study suggested that lower-ability learners may have more trouble in a horizontal skipping condition.

These two guidelines should be used with caution. This is because the generalizability of findings from this study may be determined by the type of learning hierarchies used (e.g., subject area, specific content, scope, etc.), the position of the skipped skill(s) in the hierarchy, target population, and subjects' prior knowledge directly and indirectly related to the hierarchy. More research, therefore, needs to be done with different learning hierarchies and populations before any generalizations can be made with confidence. In addition to generalizability, other issues of skipping also need further exploration, some of which are mentioned here: the position of skipped skill(s), the type of skipping (vertical or horizontal), and more specific learner attributes of those who can skip and who cannot.

This study provided a new insight to Gagne's learning hierarchies theory. Its implications may impact on the practice of classroom teachers and instructional designers regarding the instructional prescriptions given to a learner. Although not without its flaws, this study will serve its purpose if more research along this line will follow.

References

Dick, W. (1980). An alternative analysis of "Formative evaluation applied to a learning hierarchy" by White and Gagne. Contemporary Educational Psychology, 5, 282-286.

Gagne, R. M. (1962). The acquisition of knowledge. Psychological Review, 69, 355-365.

Gagne, R. M. (1968). Learning hierarchies. Educational Psychologist, 6, 2-6, 9.

Gagne, R. M. (1985). The Conditions of Learning and Theory of Instruction (4th ed.). New York: Holt, Rinehart, and Winston.

Kee, K. N., & White, R. T. (1979). The equivalence of positive and negative methods of validating a learning hierarchy. Contemporary Educational Psychology, 4, 253-259.

Trembath, R. J. & White, R. T. (1978-79). Mastery achievement of intellectual skills. Journal of Experimental Education, 47, 247-252.

White, R. T. (1974). The validation of a learning hierarchy. American Educational Research Journal, 11, 121-136.

White, R. T., & Gagne, R. M. (1978). Formative evaluation applied to a learning hierarchy. Contemporary Educational Psychology, 3, 87-94.

Yao, K. (1989). Dissertation in progress.